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Editorial

Editorial for the Special Issue "Urban Deformation Monitoring using Persistent Scatterer Interferometry and SAR Tomography"

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Abstract: This Special Issue hosts papers related to deformation monitoring in urban areas based on two main techniques: Persistent Scatterer Interferometry (PSI) and Synthetic Aperture Radar (SAR) Tomography (TomoSAR). Several contributions highlight the capabilities of Interferometric SAR (InSAR) and PSI techniques for urban deformation monitoring. In this Special Issue, a wide range of InSAR and PSI applications are addressed. Some contributions show the advantages of TomoSAR in un-mixing multiple scatterers for urban mapping and monitoring. This issue includes a contribution that compares PSI and TomoSAR and another one that uses polarimetric data for TomoSAR.

Keywords: synthetic aperture radar; persistent scatterers; tomography; differential interferometry; polarimetry; radar detection; urban areas; deformation

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Our capability to monitor deformation using satellite-based Synthetic Aperture Radar (SAR) sensors has increased substantially in recent years, thanks to the availability of multiple SAR sensors and the development of several data processing and analysis procedures. Differential interferometric SAR (DInSAR) [1] and Persistent Scatterer Interferometry (PSI) [2] involve the exploitation of at least a pair of complex SAR images to measure surface deformation. Both the DInSAR and PSI techniques exploit the phase of the SAR images. Most of the InSAR and PSI techniques assume the presence of only one dominant scatterer per resolution cell [3,4]. This assumption cannot be valid when observing ground scenes with a pronounced extension in the elevation direction for which more than one scatterer can fall in the same range-azimuth resolution cell. This potential limitation can be overcome by using SAR tomography (TomoSAR) techniques [5]. In fact, in such techniques, the use of a stack of complex-valued interferometric images makes it possible to separate the scatterers interfering within the same range-azimuth resolution cell [6,7]. This Special Issue is focused on deformation monitoring in urban areas based on PSI and TomoSAR. It collects the latest innovative research results related to these two techniques. These published papers show the capability of both techniques in mapping and monitoring urban areas.

The papers related to PSI describe methodological and application-oriented research work. In reference [8], the authors assess the deformations associated with the construction of a new metro tunnel. In reference [9], PSI results are used as a key input for geological and geomorphological analyses in urban areas. In reference [10], the subsidence phenomena over an entire metropolitan area (Rome) are studied using Sentinel-1 data and open source tools. In reference [11], the applicability for urban monitoring of pursuit monostatic data from the very high-resolution TanDEM-X mission is addressed. A new PSI procedure is described in reference [12], which is used to monitor the land deformation in an urban area induced by aquifer dewatering. The most original part of this work includes the estimation of the atmospheric phase component using stable areas located in the vicinity of the monitoring area. In reference [13], the observations coming from PSI are used to contribute to the assessment of the health state of two bridges. The use of PSI to study the long-term land deformation patterns in earthquake-prone areas is addressed in reference [14]. A methodology to exploit PSI time series from Sentinel-1 data for the detection and characterization of uplift phenomena in urban areas is described in reference [15]. In reference [16], PSI is used to identify and measure ground deformations in urban areas to determine the vulnerable parts of the cities that are prone to geohazards. In reference [17], the authors address the use of PSI data to study the pattern of temporal evolution in reclamation settlements. Finally, in reference [18], the authors study the wide-area surface subsidence characteristics of a large metropolitan area (Wuhan) using Sentinel-1 data.

In an urban environment, one of the most important tasks is to resolve layover, which causes multiple coherent scatterers to be mapped in the same range-azimuth image cell. In references [19–22] the use of tomographic techniques that synthesize apertures along the elevation direction exploiting a stack of SAR images, allows the separation of the scatterers interfering within the same range-azimuth cell. In particular, in reference [19], the detection strategy for multiple scatters is reported in the context of "tomography as an add-on to PSI", i.e., tomographic analysis is subsequent to a prior PSI processing. The paper also highlights that while the instabilities in phase are typically modeled as additive noise, their impact on tomography is multiplicative in nature. In reference [20], a Generalized Likelihood Ratio Test (GLRT) with the use of multi-look is proposed to separate multiple scatterers and shows tangible improvements in the detection of single and double interfering persistent scatterers at the expense of a minor spatial resolution loss. In reference [21], an inter-comparison of the results from PSI and TomoSAR is carried out on Sentinel-1 data. The analysis of the parameters estimated by the two techniques allows us to achieve a level of precision comparable to other studies. The paper also addresses the complementarity of the two techniques, and in particular, it assesses the increase of measurement density that can be achieved by adding the double scatterers from SAR tomography to the Persistent Scatterer Interferometry measurements. Finally, in reference [22], the use of polarimetric channels in TomoSAR is explored. This paper shows that using a GLRT approach and dual pol data is possible to reduce the number of baselines required to achieve a given scatterer detection performance.

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